## RTK GPS – Introduction

RTK is short for Real Time Kinematics. Real-time kinematic (RTK) positioning is a satellite navigation technology used to increase the precision of position data obtained from satellite positioning systems.

Traditional GNSS receivers measure how long it takes for a signal to travel from satellites to the receiver. Using 4 or more satellite signals and trilateration mathematics will enable the receiver to calculate its position. These signals, however, can get distorted when passing through the ionosphere and atmosphere affecting the calculated position accuracy (2 to 10 meters). RTK solves this issue by using real-time corrections from a base station. The base station knows its fixed position and therefore is able to estimate the errors of the received signals.

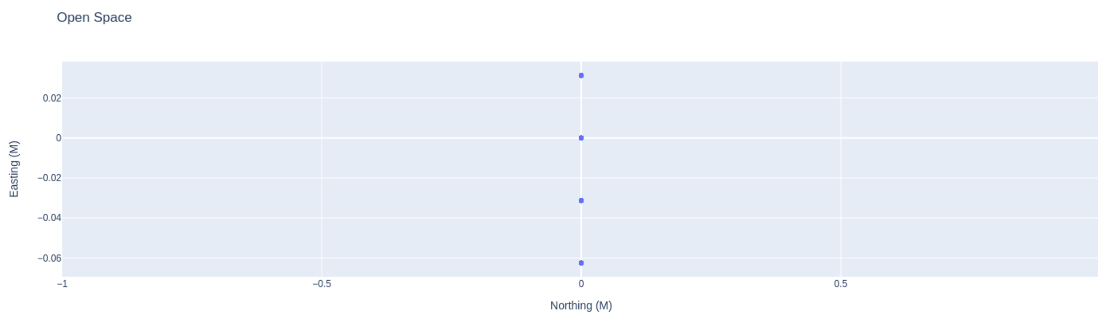
A base station consists of a GNSS receiver with known and fixed coordinates. The base station tracks the same satellites at the same time as the rover receiver. The base station is monitoring the GNSS errors and computes the position corrections. The position corrections are sent via a radio link or internet services to the rover receiver, which uses these messages to correct the real time position.

## Sources of erros in RTK GPS

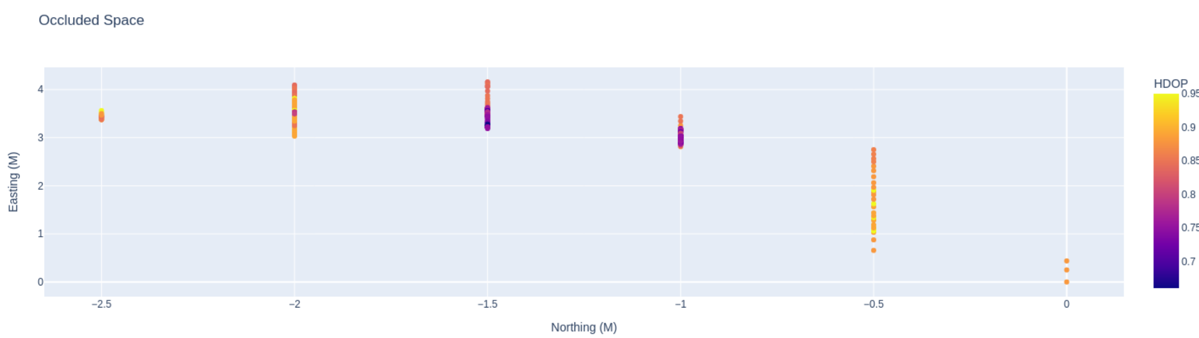
1. The place where the GPS data is recorded may not be exactly same as that of known position.
2. Interference in form of radio signals and other electromagnetic radiation or environmental activity which can cause rapid changes in the GNSS signal delay, even between receivers a few kilometers apart.
3. Error during survey of base, ie the fixed co-ordinate of the base station may be different than actual co-ordinate.
4. Moving the base after the survey, this causes the fix data to be in accurate.
5. Number of visible satellites - Even though only four satellites are needed to form a three-dimensional position fix, RTK initialization demands that at least five common satellites must be tracked at base and rover sites.
6. Operating range refers to the maximum separation between base and rover sites. Accuracy degrades and initialization time increases with range from the base

# 1. Scatter plots

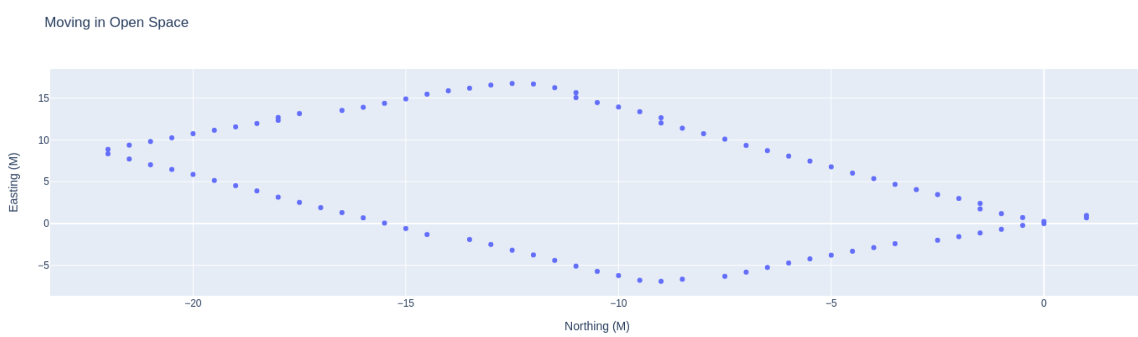
## Open Stationary



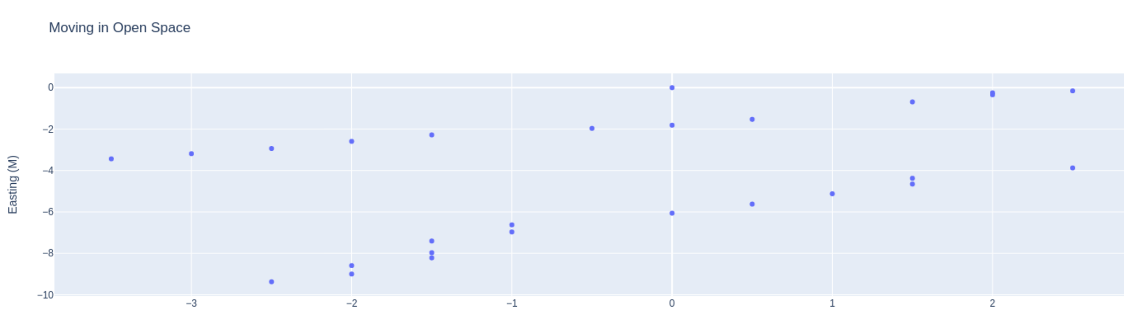

## Occluded Stationary




## Open Walking




## Occluded Walking



**a. Error in terms of true position.**

I have showed the deviation or error in terms of position in the form of scatter plot in my analysis script. We can see that the GNSS data from RTK GPS does have **higher precision than a GPS puck.** As we can see from the plot there is no change in Northing data and very small distribution of Easting data. But there seems to be a large deviation from known position. This might be due to the fact that the data was not recorded at the exact same known position.

**b. Distribution**

We already showed that RTK GPS has higher precision, and hence we can see that there is no outliers in the scatter plot. Specifically, in occluded space stationary data set, we can see that the distribution of data, and the precision varies according to the HDOP values ie yellow points are more spread than blue dots. This is opposite to what we observed in GPS puck data where the data was spread evenly across the graph irrespective of HDOP values.

**c. Reason for the distribution**

Using RTK allows the position estimate of the GNSS receiver to be significantly more accurate by compensating for inaccuracies derived from how position is estimated using standard GNSS. Standard GNSS uses the estimation of the pseudorange between satellites and the receiver to determine the receiver's position on Earth. Clock errors between the GNSS satellite and GNSS receiver as small as one microsecond will produce an error of 300 meters. By establishing a GNSS fix with four or more satellites at the same time, the receiver can solve for four unknowns: its 3-D position and its clock error with respect to the global time.

Another source of error in standard GNSS position estimation is atmospheric delays and inconsistencies that distort the radio signals between the receiver and satellite. The advantage that RTK GNSS has is that further correction information is available to mitigate the errors inherent in satellite communication. By receiving RTK correction information from a known base location relatively nearby the receiver, the atmospheric errors in the pseudorange estimation can be calculated by the base station and transmitted to the rover. By using RTK, positional data can be improved from meter-level accuracy to centimeter-level accuracy.

**d. Difference in moving data**

First thing I can see from the plots is that, the moving plot of open field is more accurate than in occluded space, as we an see a clear rectangle in the first and the second is not that clear. I think the reason is the fix quality and loss of data. In my driver, I only published and saved the data for which fix quality is 4 or more. But I observed that in occluded space the fix quality is not constant and was changing from time to time. Hence due to the chance in precision, change in quality and loss in intermediate data caused the distort path I took.

**e. Difference in stationary data**

We can see a spread of data is large in occluded space than in open space. For example in open space there is no spread along Northing data, but in occluded space small it may be, there is spread in both directions. But the fix quality for open space was 4 and the fix quality of occluded space was 5.

I think the reason for the spread is may be due to the high HDOP values, since as the HDOP value increase the data will be more imprecise or spread out. As I have shown we can see that most of the points in the plot are yellow showing high HDOP value.